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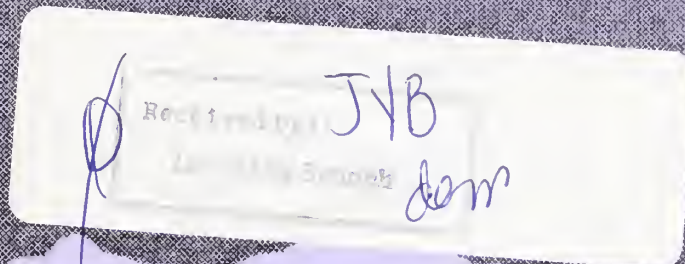
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Technical Report R2 - 59



United States
Department of
Agriculture

Renewable Resources
Forest Health Management

Forest Service
Rocky Mountain Region
Denver, Colorado



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**Interpretation of Aerial
Photography of Colorado's
Forest Health Monitoring Plots
1992 - 1995**

by

**Erik Johnson
Aerial Surveyor**

**Susan J. Johnson
FHM Biologist**

**David W. Johnson
Lakewood Service Center Leader**

**Technical Report R2-59
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**Renewable Resources
Rocky Mountain Region
USDA Forest Service
740 Simms Street
Golden, Colorado 80401**

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Introduction

In recent years, large and small-scale disturbance events, such as wildfire, land conversions, air pollution, insect and disease epidemics, have focused our collective attention on the health of our nation's forested ecosystems. The American public and forest land managing agencies are interested in understanding what long-term trends are exhibited in healthy forests, what impacts land management has on healthy forests, what practices maintain healthy forested ecosystems, and which components or combination of forest systems lead to a healthy and functioning ecosystem. In response to these environmental concerns and to legislative and policy direction, several Federal and State agencies have been working together to develop a program for monitoring and reporting on the status, trends, and change of forested ecosystem health. The Forest Health Monitoring (FHM) program was authorized in 1990 to accomplish this objective.

Program Design

The US Forest Service (FS), State Forestry, and other agriculture agencies cooperate to fulfill the FHM mission of developing and implementing a cooperative program to monitor, make assessments, and report on the long-term status, changes, and trends in the health of the nation's forest ecosystems (1994 Strategic Plan). To accomplish the mission, FHM builds on existing programs, blends non-FHM scientifically sound information with FHM information to add depth to our knowledge of forested ecosystems, and utilizes the unique and diverse expertise of all cooperators.

The FHM program is comprised of interrelated monitoring activities: Detection Monitoring, Evaluation Monitoring, Intensive Site Ecosystem Monitoring (ISEM); and Research on Monitoring Techniques (ROMT).

Detection Monitoring covers all forested lands and has two components: (1) the plot component, which is a network of permanent plots (about 4,600 for the 50 states; however, not all states are currently in the program) on which environmental indicator measurements are made annually; and (2) the survey component, which includes surveys of insect, disease, and other stressor effects, made off the FHM plot network. The purpose of Detection Monitoring is to collect information on the condition of forested ecosystems, estimate baselines and trends over time. Data from FHM plots and surveys are analyzed with other forest data to determine if changes have occurred, the cause of the changes, the significance of the changes, and if additional evaluations are warranted.

Evaluation Monitoring examines the extent, severity, and probable causes of undesirable changes in forest health beyond that provided in Detection Monitoring. Detailed information from Evaluation Monitoring identifies likely cause-and-effect relationships, proposes associations between forest health indicators, provides more detailed information for developing management options to improve forest health, and identifies additional research needs that can be met experimentally or by information from ISEM.

Intensive Site Ecosystem Monitoring conceptually provides a standard set of indicators that are monitored in detail to determine information on key components and processes of important forest ecosystems. This monitoring occurs at selected sites and allows a rigorous evaluation of cause-and-effect relationships, identifies indicators of key processes that shape forested ecosystems, and provides biological and abiotic databases that support monitoring and forest health related research at these selected sites.

Research on Monitoring Techniques (ROMT) is research specifically directed to improve all monitoring activities of the program. This research helps identify new indicators, improve current indicators, evaluate sampling designs and impacts from repeated sampling, and improve analytical and reporting methods.

Detection Monitoring - Plot Network and Sampling Design

The FHM plot sampling design is based on the Environmental Protection Agency's (EPA) Environmental Monitoring and Assessment Program (EMAP) national hexagonal base grid project. The grid has been adopted by the FHM program and produces a spatially and temporally systematic sample of approximately 15,000 points located 17 miles (27 kilometers) apart for the 50 states. Of the 15,000 sample points, approximately 4,600 fall in forested ecosystems. Each FHM plot statistically represents approximately 158,000 acres (390,413 hectares) of forested land. (See graphic designs of global, state/forest, single plot configuration, Figures 1, 2, & 3.)

Implementation of the plot network in Colorado is the responsibility of the US Forest Service, Interior West Resource Inventory, Monitoring and Evaluation Unit, Ogden, Utah. In 1992, one-quarter of the field plots were established in Colorado, with completion of a cycle in 1995. In 1996, new FHM policy stated that the year a state was added to the program, the entire suite of field plots would be established. Additionally, one-third of the plots from the previous year would be visited again the following year. This meant that in 1996 when remeasurement of one-quarter of the 1992 plots was scheduled, an additional one-third of the Colorado plots established in 1995 was remeasured as well. There is a total of 151 FHM plots in Colorado.

Measurements on the FHM plots involve seven indicators or data groups: (1) forest mensuration indicators - tree growth, mortality, and regeneration; (2) crown condition - dieback, density, and foliage transparency; (3) tree damage indicators - conks, excessive branching, resinosis, etc.; (4) lichen community composition; (5) photosynthetically active radiation (PAR) readings; (6) vegetative diversity ozone bioindicator plants; and (7) soil indicators still under development. In 1997, soil samples will be taken on one-quarter of the FHM plots in Colorado (See Appendix A).

Detection Monitoring - Survey Component

The FHM Survey Component in Colorado is the responsibility of the Forest Health Management Unit of the Rocky Mountain Region and is an enhancement of traditionally delivered information and assistance. Forest Health Management provides forest health technology transfer and support directly to the National Forest System, other federal forest resource managers, and through state agencies to resource managers of state and private lands.

The survey component is intended to provide a record of broad scale disturbance events on an annual basis, complimenting long-term trend information from plot data and analysis and establishing baseline information. Methods by which the survey component of Detection Monitoring are satisfied are:

- annual aerial surveys to detect insect, disease, and abiotic damage;
- ground surveys for specific insect and diseases such as Armillaria root disease, dwarf mistletoe, mountain pine beetle and Douglas-fir beetle;

- analysis of other plot-based data from Forest Inventory and Analysis (FIA), National Forest inventories, and Forest Health Management insect and disease plot inventories;
- Forest Health Management service trip reports, biological evaluations, biological assessments and technical reports for historical data or trends, and the focus of this report;
- utilization of aerial photography in appropriate situations and with specifically defined objectives.

As field plots were installed in Colorado, one-quarter of the total over 4 years, the Rocky Mountain Region Forest Health Management Unit contracted with the former Methods Application Group, currently known as the Forest Health Technology Enterprise Team, to acquire resource photography of the plots with the intention of capturing vegetative status directly on and adjacent to FHM plots and to provide a database for future analyses.

In 1995, FHM plot installation and the associated photography mission were completed for Colorado. In the following months, with the assistance and cooperation of the Methods Application Group, the Interior West Resource Inventory, Monitoring, and Evaluation Unit, and the Rocky Mountain Region Forest Health Management Unit, protocols and techniques were developed in support of the eventual photointerpretative work to be done on the FHM plot photography.

The following information is provided to document the methods and results of interpreting 139 photos, thus, establishing baseline data in support of the FHM mission. Of the photography, 12 photographic series require additional analysis. In the future, a series of FHM plot photographs will again be taken to compliment the 1992-1995 FHM aerial plot photography, thereby providing data to evaluate occurrences of trends and/or detect change.

Materials and Methods

Many of the techniques used to prepare the photographs, equipment for interpretation, and basic photointerpretation skills are well documented in available natural resource manuals, (i.e., Caylor, 1988, Ward, 1988, and Croft, Heller, and Hamilton, Jr. 1982).

Aerial photography of FHM plots and photointerpretation of those photos are intended to assist in the development of baseline data for change detection in forested ecosystem where FHM plots are located. The survey component of Forest Health Detection Monitoring was implemented using the following specifications and parameters of aerial photography and the corresponding photointerpretation of the photos within a 25-acre circle around the plot center.

Aircraft

For 1992 and 1993, the Methods Application Group used a B-80 Beech Craft Queen Air for acquisition of aerial photography. In 1994 and 1995, the same contractor used a A-100 Beech Craft King Air.

Camera

For all years, a Zeiss camera, model RMK 21/23, focal length 8.25" was used to acquire FHM photography.

Film and Processing

A film format of 9" X 9" was used for all years with differences in type of film per year. In 1992, Aerochrome color infrared film (#2443) was used. For 1993, 1994, and 1995, Aerocolor negative film (#2445) was used. The color infrared film, #2443, used in 1992, was preferred by the interpreter for the more recognizable stressor signatures and more easily identified mortality as compared to the true color prints, #2445, of the later photography.

Sleeving Methods

Forest Health Monitoring plot photographs were placed in photo sleeves for protection. The source of the 10" X 10" - LHA (lip/folded one side with lip on opposite side, heavy 4.5 mm. gauge material, acetate) sleeves was the Picture Pocket Company, San Marcos, California. Each photo was placed inside the sleeve and taped to the back of the sleeve to prevent photo movement. Fiducial marks and frame numbers were outlined on the sleeve to register the photo to the sleeve. Each photo was labeled with the plot number, 7.5" quadrangle map name, originating year, and actual scale.

Scale Equations for Photography and 25-acre Circle Template

To determine actual scale of the aerial photography, 7.5 minute orthophoto and topographical quadrangle maps corresponding to plot location were used. The distance between two points on the photography and two corresponding points on the quadrangle map(s), where elevation is the same, were measured. These values were inserted into the equation, $PSR = MD(MSR) / PD$, where PSR = photo scale reciprocal, MD = map distance, MSR = map scale reciprocal, and PD = photo distance. The flying height above mean sea level (MSL) was determined by using the formula $H = f (PSR)$, where H = flying height above ground level, and f = focal length of the camera. The value for focal length is usually found within the title block of an aerial photo. Once H was calculated, MSL was determined by using the equation $MSL = H + e$, where e = elevation. MSL was calculated and written on each plot photo of the stereo pair for future reference and more in-depth interpretation such as estimating tree heights and elevational differences within the 25 acre analysis area. With a known MSL, the scale at any elevation can be determined by equation manipulation. For instance, e of plot center is subtracted from MSL to determine a new H, where $H = MSL - e @ \text{plot center}$. Knowing H (flying height above ground level, and f (focal length), a new PSR for plot center is calculated using the equation, $PSR = H/f$. Actual photo scale is then PSR divided into 1. The corresponding 25-acre plot template was selected to match the scale of the plot center on the photograph.

As cooperators designed the photointerpretation system for the FHM aerial photography, data available through photointerpretation was evaluated. Also, resource elements that would compliment and be relevant to information gathered on the plot and within a larger traditional program of Forest Health Management detection of insect and disease disturbance context were recorded. A 25-acre circle around plot center was designed to capture vegetative status directly adjacent to the FHM plot and identify forest conditions relative to the plot hexagon design. Use of a circle as an interpretation area is a simple and uniform analysis construct. When employing the shape of a circle for an analysis area, the most important step to follow was selection of an appropriately scaled 25-acre template; orientation of the template along directional biases was eliminated.

Photointerpretation Form

For each photo, the interpreter recorded specific information including host type, mortality, and stressed trees, with general remarks for each entry.

Stereoscope Information

All FHM aerial plot photography was evaluated using an Old Delft Scanning Stereoscope, model ODSS III. Magnification for photointerpretation work was 4.5X.

Polygon Delineation and Numbering Scheme: Analysis of 25-acre area centered on FHM plot center

Trees appearing stressed or areas of mortality were delineated on the acetate sleeves using a black marker of ultra fine thickness. Several trees in a discrete group or clump were identified with a polygon. Individual trees or a few small trees together were identified with a point. Polygons identifying contiguous groups were always identified even if a section of the polygon fell outside of the analysis area of the 25-acre circle. In this situation, only the trees within the 25-acre analysis area were counted. Polygons were numbered in a manner that was reasonable to the photointerpreter and varied from interpreter to interpreter.

Tree Number Estimates

Stressed and/or dead trees were counted in each point and polygon. When a polygon extended outside of the 25-acre analysis area, only the trees within the template circle were counted. Numbers of trees were estimated only when too many trees were present or too small for individual recognition due to limited resolution. To make estimates, polygons were mentally divided up into equal separate sections, all trees were counted in one of the sections, and tree number was then multiplied by the total number of "mental" polygon sections for total polygon tree estimate. If a polygon was located inside or extending onto another polygon, trees were labeled and counted separately: for example, different tree species; same species, different stressor(s); and/or dead trees within stressed tree polygon.

Stressor Agents

Stressor agents or causal agents were determined based on acquired photointerpretation skills, knowledge of and experience with insect and disease signatures, and knowledge of historic events, and presence of stressors. Also, identification of stressors was more accurate in epidemic situations.

Of all the stresses in the forested ecosystems, subalpine fir decline, which is poorly understood but thought to be a combination of *Armillaria* and other root diseases and the western balsam bark beetle, in subalpine fir and corkbark fir, was the most identifiable in the FHM aerial photography. Additionally, based on investigative knowledge, this complex is the most active stressor in the spruce/fir coevertype throughout the inter-mountain west.

Other recognizable stressors interpreted from the FHM aerial photography were: topkill, most commonly associated with the feeding patterns of western spruce budworm on Douglas-fir; declining trees in lodgepole pine and ponderosa pine due to mountain pine beetle activity; and

finally, abiotic disturbances of water damage and wind-throw. Discoloration of aspen and gambel oak in some ecosystems was also noted; however, the actual cause was not identified.

Resources, such as Ward, James F., 1988, and very complete field notes taken from the Forest Health Monitoring plots, assisted in a higher degree of photo evaluation confidence.

Ideally, ground-truthing and verifying the data interpreted from the photography should occur for calibration and training of interpreters. Several members of the Rocky Mountain Forest Health Management Unit have done ground-truthing at a small scale. These results have not been documented.

Host Species

Host species data was gathered from the Forest Health Monitoring plot photography using field notes and photointerpretation. Identification of each species requires the interpreter to see unique characteristics of each tree species such as texture, color, size, and shadow. Additionally, elevation, aspect, regional knowledge, and an understanding of tree growth requirements were used to determine species identification.

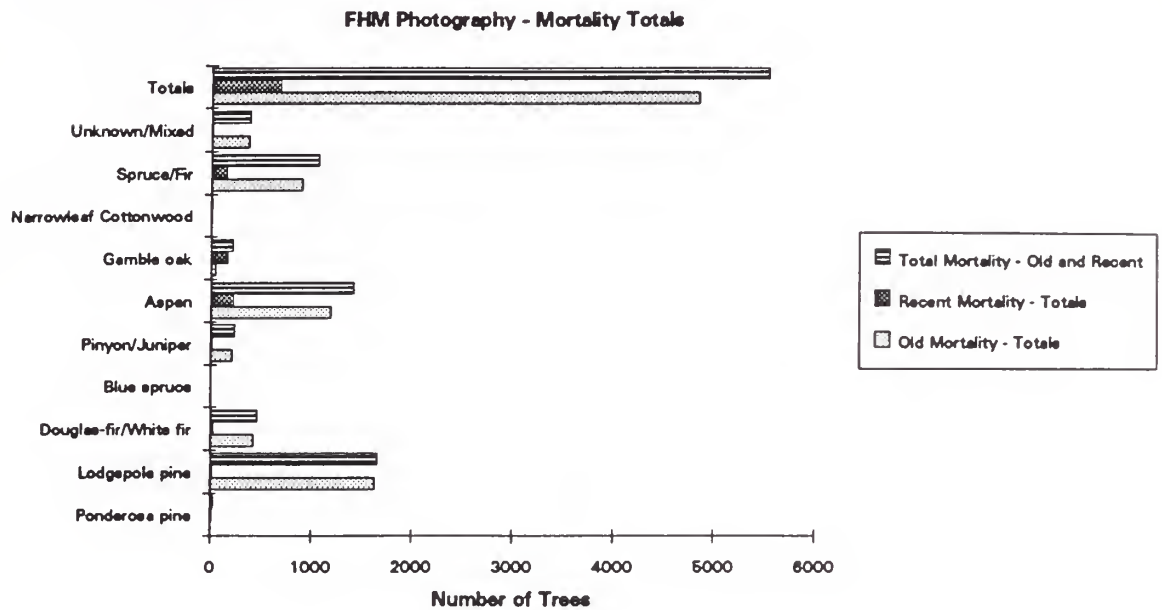
Transitional and mixed stands were the most difficult to evaluate for host species. In these complex and diverse landscapes, attempts to classify trees to species were dismissed.

Host species was assigned to mortality in relation to the surrounding vegetative composition. It was assumed that the dead tree(s) was the same species as the living trees in the stand. Again, host species of mortality in transitional and mixed stands were not classified.

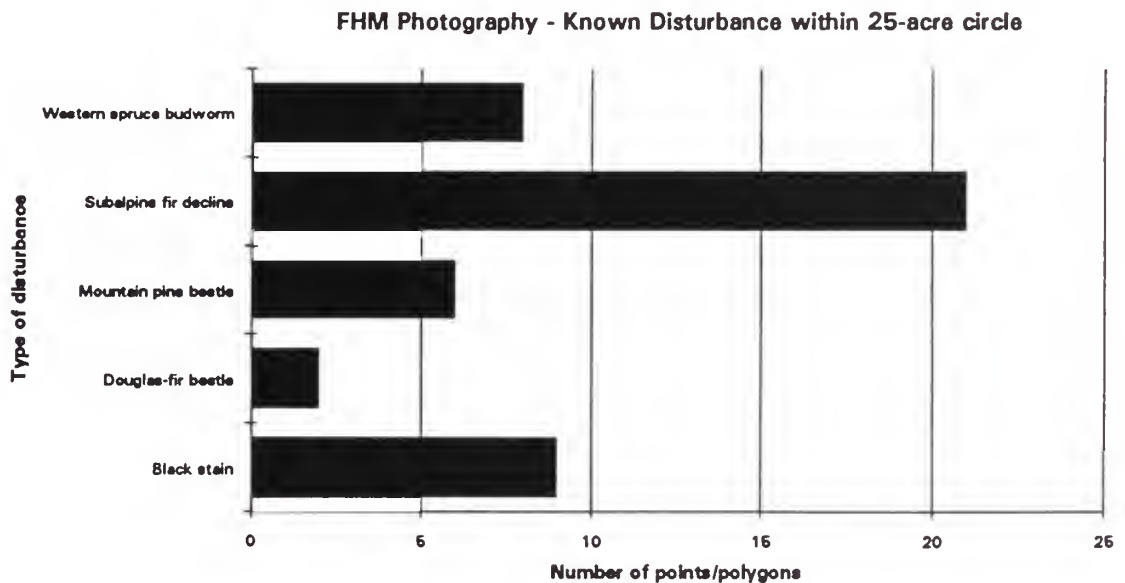
Results

The Forest Health Monitoring Plot Photography of 1992 - 1995 consists of 139 fully interpreted photo pairs and an associated database establishing a baseline record of vegetative and disturbance conditions. Of the FHM photography set, 12 photo pairs are in a pre-interpretation stage. In the future, when a companion series of FHM plot photography is taken, this investment will pay off by delivering an unbiased comparative dataset (2 sets of photography of the same site) which photointerpreters can analyze and track long-term change of Colorado's forested ecosystems.

The following results are intended to be one of the analysis components to assess future change in these forested ecosystems.

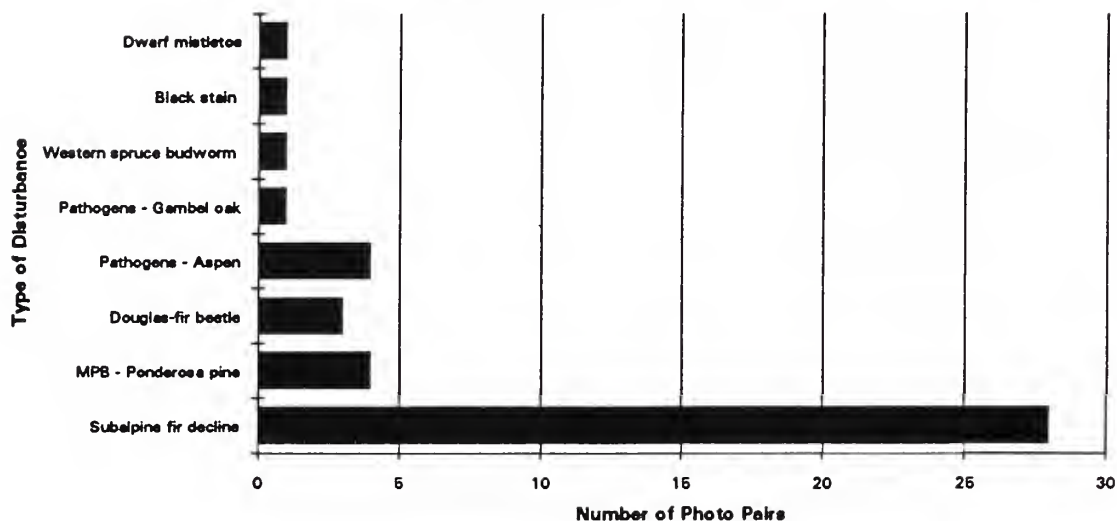


The FHM Photography - Mortality Totals graph represents the first filtering of the data that resulted in 659 total polygons with mortality, within the total number of polygons, 538 points/polygons were considered "old", while 121 points/polygons were considered "recent" mortality. The greatest amount of mortality was noted in lodgepole pine, aspen, and spruce/fir, respectively.



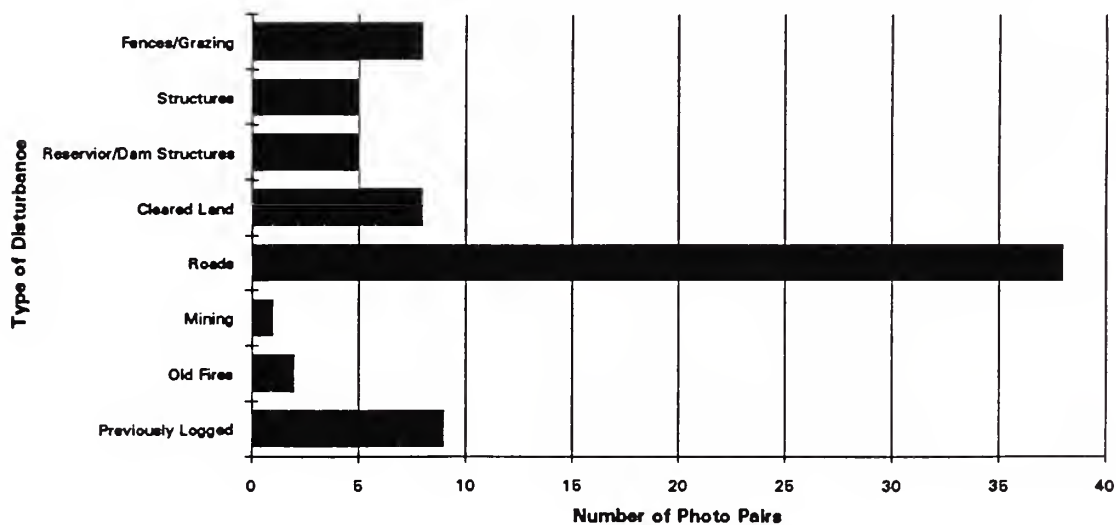
The FHM Photography - Known Disturbance graph represents the known disturbance agents of the 121 individual trees recorded as "recent" mortality. As shown in the graph, of the 121 recorded incidences of recent mortality, 46 incidences were attributed to known or specific element. Subalpine fir decline was attributed as the most frequent disturbance agent in the photography.

FHM Photography - Biotic Disturbance Outside of 25-acre circle

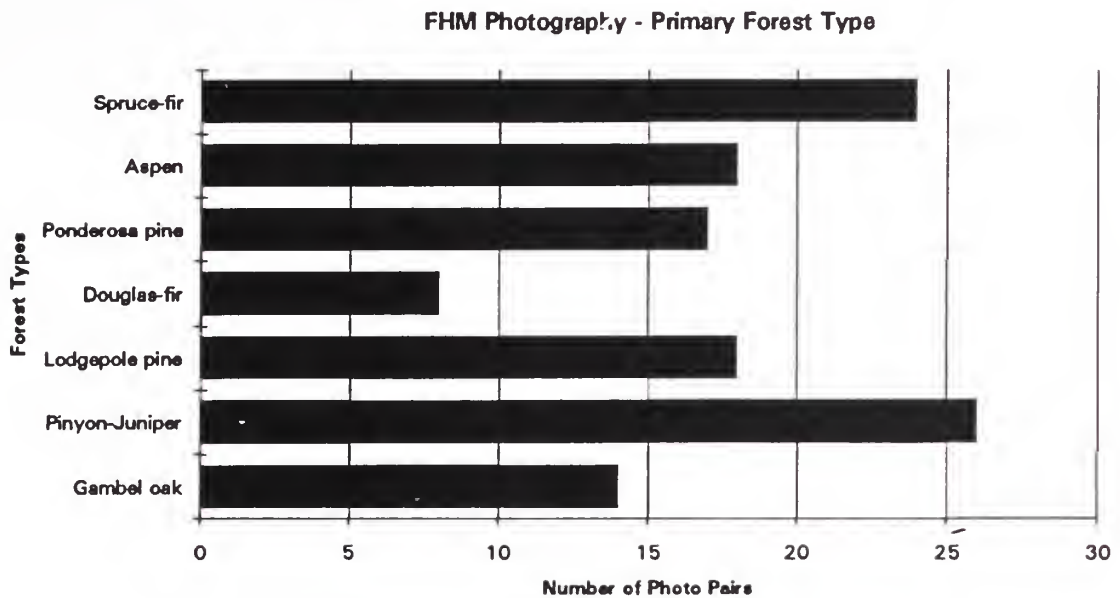


The FHM Photography - Biotic Disturbance graph represents the type of disturbance outside of the 25-acre analysis area associated with the plot photographs. These disturbances may or may not influence plot conditions and are important to record for future reference. Subalpine fir decline was again the most frequently noted disturbance.

FHM Photography - Abiotic Disturbances Inside 25-acre circle



The FHM Photography - Abiotic Disturbance graph represents the type of disturbance inside the 25-acre analysis area associated with the plot photographs. These disturbances may or may not influence plot conditions and are important to record for future reference. Fire and land conversions will most likely be activities associated with the most disturbance in the future.



The FHM Photography - Primary Forest Type was determined from Forest Health Monitoring field crew notes and the major vegetation classification as observed during plot installation. Pinyon-juniper was the most common type followed by spruce-fir and aspen.

Conclusion and Recommendations

Repeat aerial photography of the FHM plots will achieve the desired objective of monitoring long-term change in a forested ecosystem. Aerial photography has several characteristics which make it advantageous for tracking change; standardization of the data - most photographic features are available to repeat photography yielding comparable data sets; large quantities of information are captured in photography which can be interpreted in different ways; new photointerpretation skills or techniques may be applied to photography if developed in the future; and ultimately, if photography is kept in good condition, evidence of large scale, long-term change over time is documented.

Aerial photography can be a reasonable allocation of resources when repeated photography serves to balance two critical decision elements: monetary investment and appropriate repeat intervals which capture change in the natural system. For example, if disturbance regimes in Colorado forest systems are used to determine repeat photography intervals, short interval disturbance regimes, such as the ponderosa pine type would be photographed every 5 to 10 years, contrasted with subalpine fir forest disturbance regimes of 100 to 200 years. However, as interpreted from the initial set of FHM photography, the subalpine fir forests appear to have more mortality at this time. In any event, several pressures besides fire, insects, diseases, and other abiotic disturbance events are changing the forests. In some cases, these changes are occurring at accelerated rates and independent of the regulating effects of natural disturbance. Management objectives of the land should also be part of the photography decision criteria. For instance, plots located within areas designated as wilderness may not need to be photographed as regularly as Colorado Front Range plots.

Obtaining the best value from FHM plot repeat photography requires evaluation of several factors in relation to each other. The first year a state is brought into the program, baseline photography should be encouraged. After the first year, budgets, change probabilities, disturbance regimes and patterns, will dictate FHM plot photography repeat intervals. To date, a schedule for Region 2 FHM plot repeat photography for Colorado is in the analysis phase.

Recommendations for future FHM photography acquisition are as follows:

- Colorado topography and associated vegetation are sufficiently addressed by using a scale range of 1:6,000 to 1:7,500 for aerial photography;
- areas of known disturbance are potential candidates for "regular" photography; "regular" is defined by specific regional/local resources;
- use FHM field crew notes to document and determine the need for repeat photography; integrate field observations into photo acquisition program;
- add an abiotic disturbance category to the photointerpretation data sheet;
- use GIS capabilities when possible, particularly to assess acreage totals;
- integrate information from other detection sources, such as aerial survey, to trigger photography or a physical monitoring of the FHM plot;
- a comprehensive aerial photographic and interpretative program must include ground visits by the interpreter to verify accuracy - quality control.

The following sections of this report represent the conceptual framework of the FHM network and graphics of plot location in Colorado, what a plot looks like and design elements of every FHM plot. Part of the photointerpretation design for the photography was a mylar template and datasheet which are also including for documentation purposes. Finally, two tables of actual data obtained from the photography is included, as well as a list of plot indicators recorded on every plot.

Acknowledgments

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Colorado Forest Health Monitoring

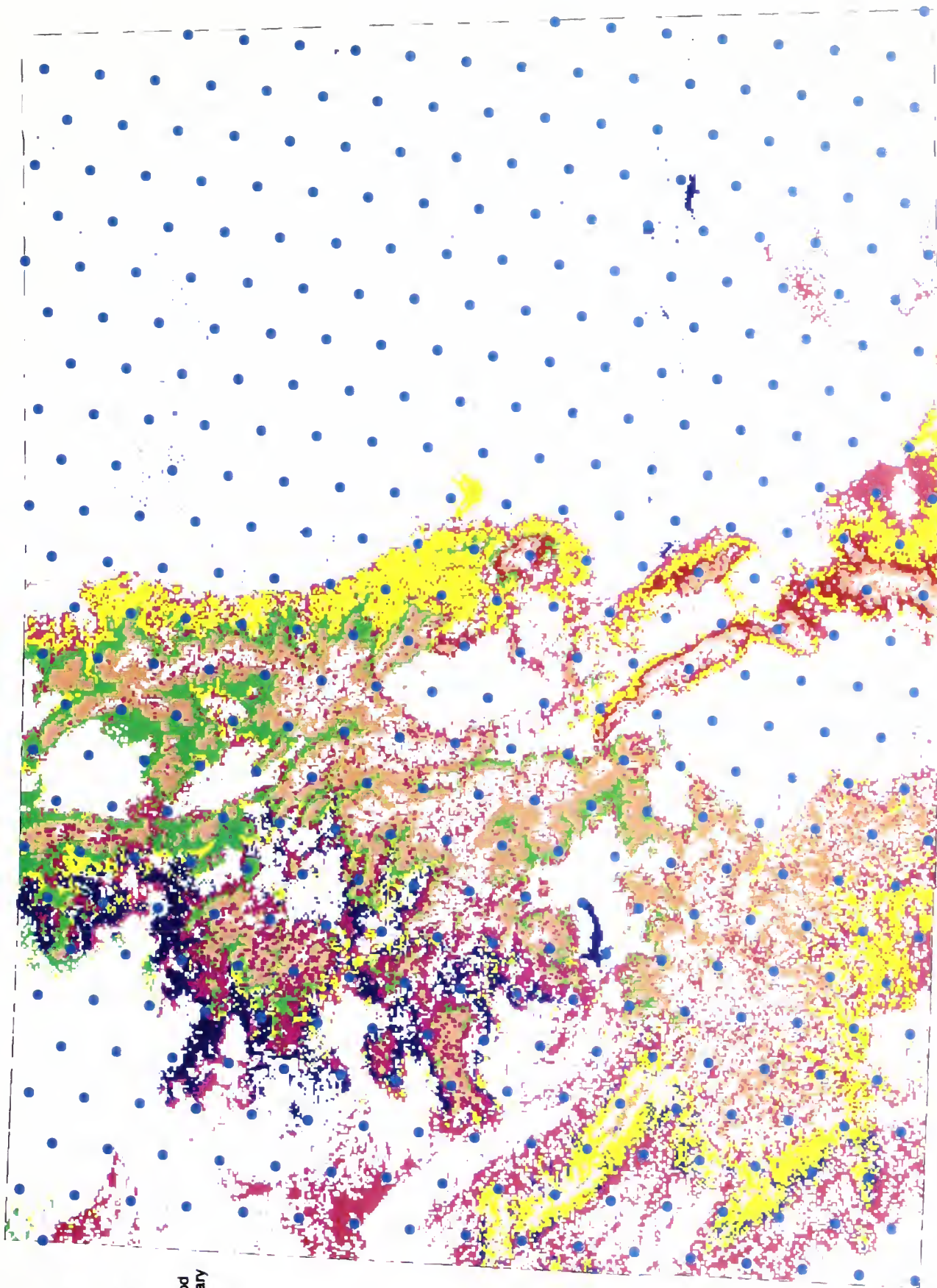


Figure 1

National FHM Field Plot Design

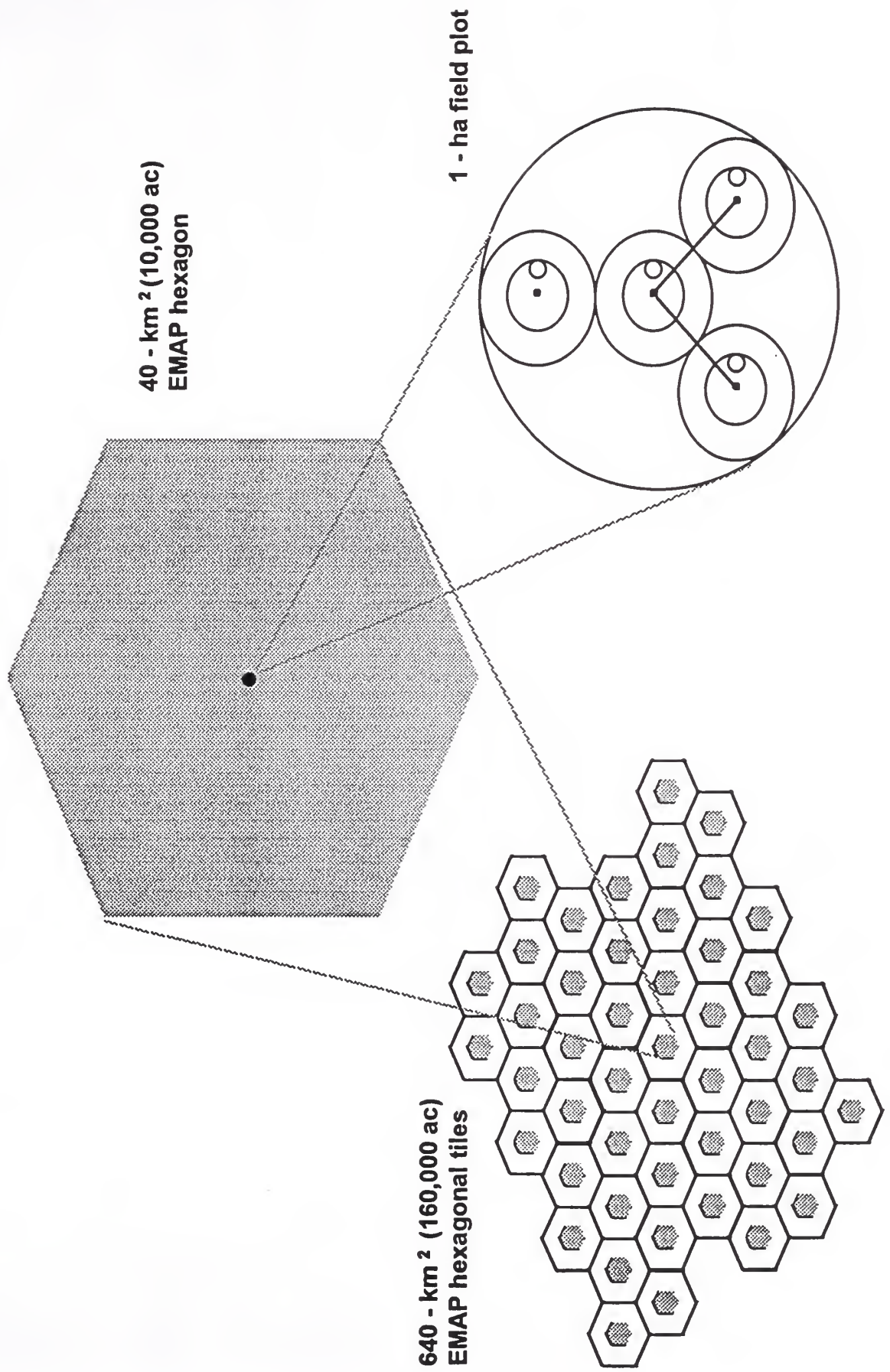


Figure 2

National FHM Plot Layout

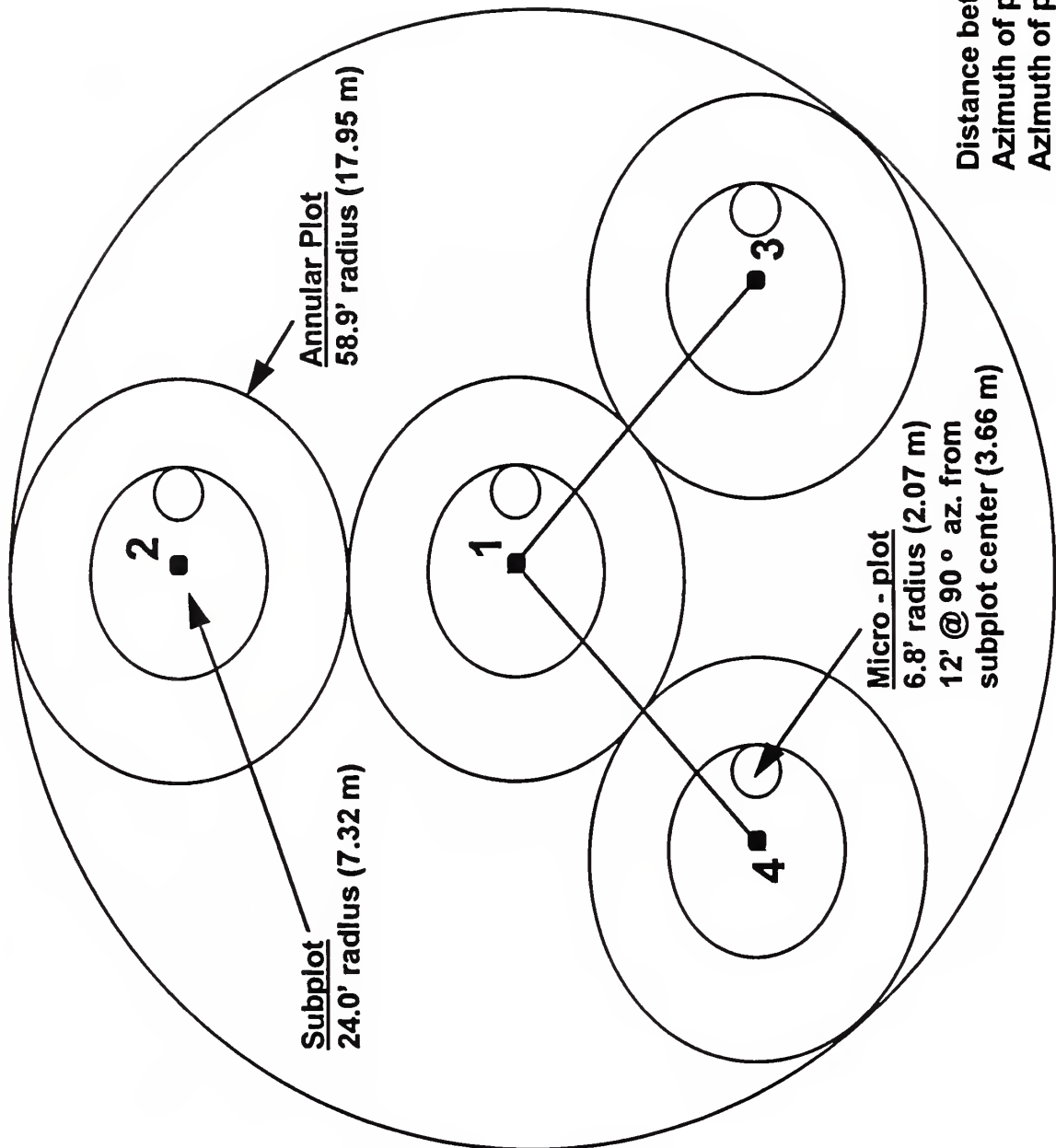


Figure 3

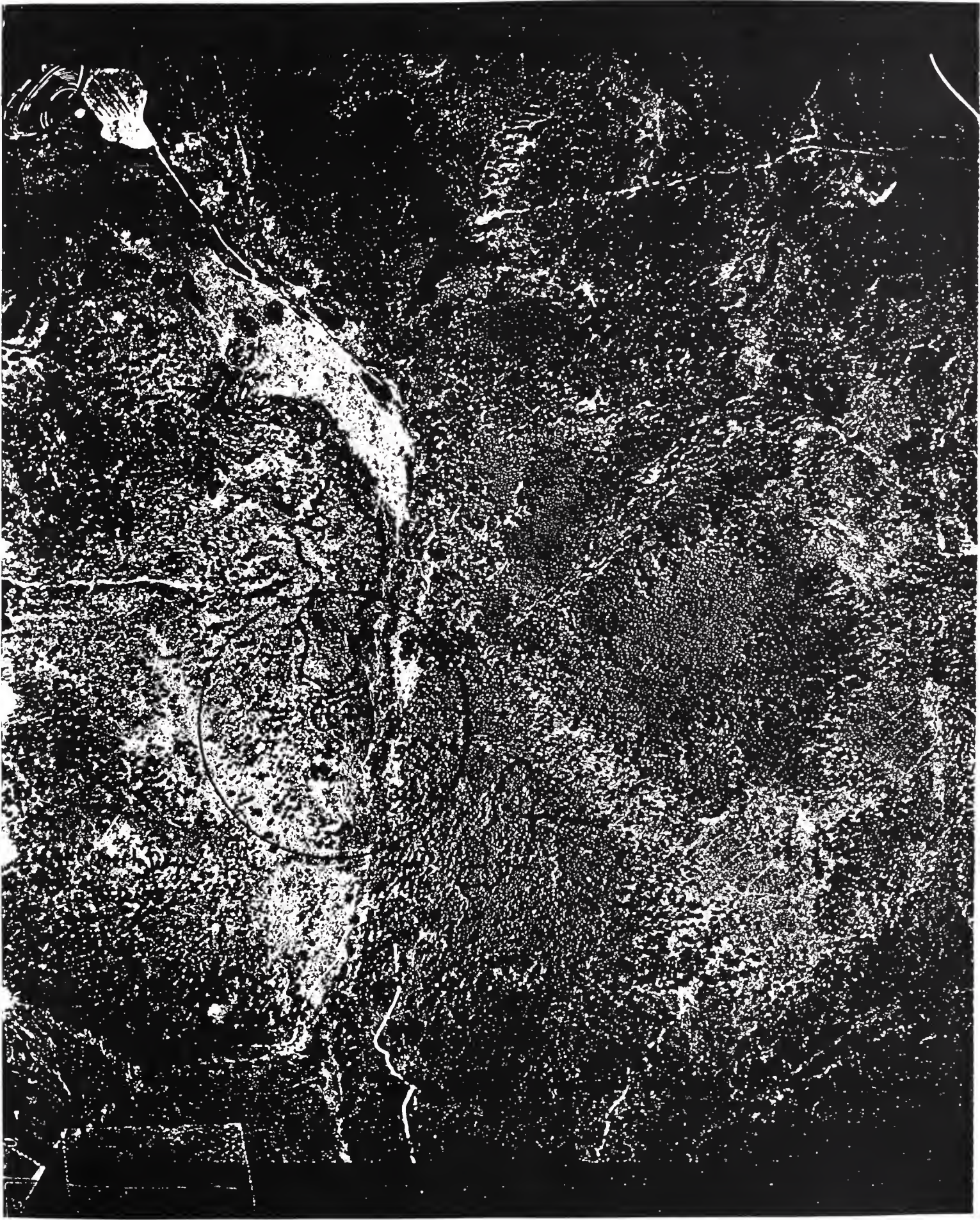


Figure 4

INTERPRETATION RECORD

DATE OF PHOTOGRAPHY 8/6/94

Figure 5

Table 1

FHM Photointerpretation Records 1992-1995

Plot Number	Year of Photography	Date of Interpretation	Interpreter Name	Actual Scale	Frame Numbers	Photo type
3710314	1995	3/21/96	E. Johnson	1:6657	028/029	NC
3710345	1995	3/20/96	E. Johnson	1:6982	022/023	NC
3710353	1993	3/6/95	E. Johnson	1:6498	064/065	NC
3710365	1994	1/17/95	E. Johnson	1:7000	064/065	NC
3710414	1993	3/8/95	E. Johnson	1:6450	053/054	NC
3710416	1995	3/20/96	E. Johnson	1:6754	017/018	NC
3710436	1995	3/13/96	E. Johnson	1:7067	012-014	NC
3710448	1993	3/8/95	E. Johnson	1:7133	047/048	NC
3710488	1993	3/8/95	E. Johnson	1:6638	070/071	NC
3710532	1995	3/21/96	E. Johnson	1:7200	035/036	NC
3710552	1994	1/18/95	E. Johnson	1:6786	083/084	NC
3710615	1992	4/20/95	E. Johnson	1:7294	144/145	CIR
3710623	1994	1/18/95	E. Johnson	1:7090	141/142	NC
3710627	1995	3/19/96	E. Johnson	1:6213	003/004	NC

Plot Number	Year of Photography	Date of Interpretation	Interpreter Name	Actual Scale	Frame Numbers	Photo type
3710643	1995	3/20/96	E.Johnson	1:6770	008/009	NC
3710647	1994	1/18/95	E.Johnson	1:7050	184/185	NC
3710655	1992	4/22/95	E.Johnson	1:6809	150/151	CIR
3710667	1995	5/13/95	E.Johnson	1:6919	009/010	NC
3710712	1993	3/8/95	E.Johnson	1:7152	026/027	NC
3710716	1992	4/22/95	E.Johnson	1:6949	132/133	CIR
3710724	1994	1/18/95	E.Johnson	1:6598	179/180	NC
3710731	1993	4/22/95	E.Johnson	1:7018	075/076	NC
3710736	1993	3/8/95	E. Johnson	1:6874	020/021	NC
3710743	1995	5/13/96	E.Johnson	1:7000	99/100	NC
3710748	1994	1/19/95	E.Johnson	1:6682	189/190	NC
3710751	1993	3/8/95	E.Johnson	1:7415	069/070	NC
3710771	1993	4/22/95	E.Johnson	1:6459	060/061	NC
3710783	1995	3/13/96	E.Johnson	1:7086	100-102	NC
3710824	1994	1/19/95	E.Johnson	1:6694	170/171	NC
3710832	1992	4/22/95	E.Johnson	1:7300	126/127	CIR

Plot Number	Year of Photography	Date of Interpretation	Interpreter Name	Actual Scale	Frame Numbers	Photo type
3710844	1995	5/14/96	E. Johnson	1:6834	035/036	NC
3710852	1993	3/10/95	E. Johnson	1:7227	009/010	NC
3710856	1993	4/24/95	E. Johnson	1:6849	121/122	NC
3710858	1994	1/19/94	E. Johnson	1:6635	161/162	NC
3710864	1994	1/24/95	E. Johnson	1:7141	193/194	NC
3710872	1992	4/24/95	E. Johnson	1:6888	110/111	CIR
3710876	1993	3/10/95	E. Johnson	1:7037	033/034	NC
3710888	1994	1/24/95	E. Johnson	1:7167	201/202	NC
3810487	1993	3/10/95	E. Johnson	1:6659	088/089	NC
3810512	1994	1/24/95	E. Johnson	1:7200	123/124	NC
3810516	1995	3/19/96	E. Johnson	1:69500	044/045	NC
3810524	1993	3/10/95	E. Johnson	1:6925	037/038	NC
3810531	1995	5/8/96	E. Johnson	1:7079	039/040	NC
3810536	1994	1/24/95	E. Johnson	1:7385	078/079	NC
3810548	1993	3/10/95	E. Johnson	1:6982	029/030	NC
3810551	1994	1/24/95	E. Johnson	1:6821	053/054	NC

Plot Number	Year of Photography	Date of Interpretation	Interpreter Name	Actual Scale	Frame Numbers	Photo type
3810556	1995	5/8/96	E. Johnson	1:7296	043/044	NC
3810563	1993	3/10/95	E. Johnson	1:6920	024/025	NC
3810571	1995	5/8/96	E. Johnson	1:6979	049/050	NC
3810615	1992	4/24/94	E. Johnson	1:6632	157/158	CIR
3810632	1995	3/14/96	E. Johnson	1:6624	040/041	NC
3810634	1993	3/10/95	E. Johnson	1:7186	088/089	NC
3810652	1994	1/25/95	E. Johnson	1:7094	117/118	NC
3810666	1996	5/9/96	E. Johnson	1:7500	015/016	NC
3810672	1995	5/14/96	E. Johnson	1:7000	013/014	NC
3810678	1992	4/24/95	E. Johnson	1:6600	027/028	CIR
3810684	1992	4/24/95	E. Johnson	1:7300	022/023	CIR
3810686	1995	5/9/96	E. Johnson	1:6810	025/026	NC
3810711	1993	3/10/95	E. Johnson	1:7003	054/055	NC
3810715	1992	4/24/95	E. Johnson	1:7200	169/170	CIR
3810723	1994	1/25/95	E. Johnson	1:7044	145/146	NC
3810731	1993	4/24/95	E. Johnson	1:7000	047/048	NC

Plot Number	Year of Photography	Date of Interpretation	Interpreter Name	Actual Scale	Frame Numbers	Photo type
3810763	1994	1/25/95	E.Johnson	1:6722	060/061	NC
3810767	1995	5/14/96	E.Johnson	1:6801	019/020	NC
3810775	1993	4/17/95	E.Johnson	1:7037	035/036	NC
3810782	1995	3/13/96	E.Johnson	1:7209	106-108	NC
3810812	1993	4/17/95	E.Johnson	1:6994	005/006	NC
3810816	1992	4/24/95	E.Johnson	1:7190	103/104	CIR
3810824	1994	1/26/95	E.Johnson	1:6291	156/157	NC
3810828	1995	5/14/96	E.Johnson	1:6970	050/051	NC
3810836	1993	4/17/95	E.Johnson	1:6857	028/029	NC
3810843	1995	5/14/96	E.Johnson	1:6945	026/027	NC
3810856	1992	4/24/95	E.Johnson	1:6630	097/098	CIR
3810863	1994	1/26/95	E.Johnson	1:6623	206/207	NC
3810868	1995	5/9/96	E.Johnson	1:6748	055/056	NC
3810875	1993	4/17/95	E.Johnson	1:6920	021/022	NC
3810888	1994	1/26/95	E.Johnson	1:6720	081/082	NC
3910424	1994	1/26/95	E.Johnson	1:6566	032/033	NC

Plot Number	Year of Photography	Date of Interpretation	Interpreter Name	Actual Scale	Frame Numbers	Photo type
3910436	1993	4/17/95	E.Johnson	1:7078	011/012	NC
3910458	1994	1/26/95	E.Johnson	1:6375	038/039	NC
3910511	1994	1/30/95	E.Johnson	1:7200	072/073	NC
3910523	1993	4/17/95	E. Johnson	1:6571	018/019	NC
3910535	1994	1/30/95	E. Johnson	1:7385	028/029	NC
3910543	1992	4/24/95	E.Johnson	1:6407	054/055	CIR
3910547	1993	4/17/95	E. Johnson	1:6810	112/113	NC
3910555	1995	3/19/96	E.Johnson	1:7032	012/013	NC
3910562	1993	4/18/95	E.Johnson	1:6525	005/006	NC
3910567	1993	4/26/95	E.Johnson	1:6293	119/120	NC
3910574	1994	1/30/95	E.Johnson	1:6806	021/022	NC
3910587	1993	4/18/95	E.Johnson	1:7002	125/126	NC
3910611	1994	1/30/95	E.Johnson	1:7291	114/115	NC
3910626	1995	5/10/96	E.Johnson	1:7939	031/032	NC
3910636	1994	1/30/95	E.Johnson	1:6328	089/090	NC
3910643	1992	4/26/95	E.Johnson	1:6120	050/051	CIR

Plot Number	Year of Photography	Date of Interpretation	Interpreter Name	Actual Scale	Frame Numbers	Photo type
3910658	1993	4/19/95	E. Johnson	1:6939	015/016	NC
3910663	1993	4/19/95	E. Johnson	1:6642	106/107	NC
3910671	1995	5/10/96	E. Johnson	1:6568	024/025	NC
3910715	1993	4/26/95	E. Johnson	1:6763	027/028	NC
3910727	1995	3/13/96	E. Johnson	1:7576	133-135	NC
3910734	1993	4/18/95	E. Johnson	1:7005	019/020	NC
3910742	1996	3/13/96	E. Johnson	1:6931	117-119	NC
3910746	1994	1/31/95	E. Johnson	1:7000	006/007	NC
3910762	1994	1/31/95	E. Johnson	1:6968	051/052	NC
3910774	1993	4/19/95	E. Johnson	1:6920	012/013	NC
3910778	1992	4/26/95	E. Johnson	1:6918	032/033	CIR
3910811	1993	4/18/95	E. Johnson	1:6777	138/139	NC
3910835	1993	4/18/95	E. Johnson	1:6460	133/134	NC
3910843	1995	5/14/96	E. Johnson	1:6743	087/088	NC
3910847	1994	1/31/95	E. Johnson	1:7262	011/012	NC
3910851	1993	4/19/95	E. Johnson	1:6973	020/021	NC

Plot Number	Year of Photography	Date of Interpretation	Interpreter Name	Actual Scale	Frame Numbers	Photo type
3910855	1992	4/27/95	E. Johnson	1:6667	024/025	CIR
3910867	1995	5/9/96	E. Johnson	1:6593	013/014	NC
3910875	1993	4/18/95	E. Johnson	1:6987	027/028	NC
3910883	1995	5/14/96	E. Johnson	1:6592	081/082	NC
4010514	1996	5/10/96	E. Johnson	1:7118	030/031	NC
4010534	1994	1/31/95	E. Johnson	1:5974	012/013	NC
4010538	1995	3/14/96	E. Johnson	1:7259	001-005	NC
4010546	1993	4/19/95	E. Johnson	1:6724	077/078	NC
4010554	1995	5/8/96	E. Johnson	1:7460	003/004	NC
4010558	1994	1/31/95	E. Johnson	1:6441	095/096	NC
4010566	1992	4/27/95	E. Johnson	1:6750	060/061	CIR
4010578	1995	5/13/96	E. Johnson	1:7103	007/008	NC
4010586	1993	4/19/95	E. Johnson	1:7093	083/084	NC
4010611	1994	1/31/95	E. Johnson	1:7102	007/008	NC
4010615	1995	5/10/96	E. Johnson	1:6822	018/019	NC
4010617	1993	4/19/95	E. Johnson	1:6875	009/010	NC

Plot Number	Year of Photography	Date of Interpretation	Interpreter Name	Actual Scale	Frame Numbers	Photo type
4010623	1993	4/20/95	E. Johnson	1:6690	003/004	NC
4010627	1992	4/27/95	E. Johnson	1:6783	019/020	CIR
4010667	1993	4/28/95	E. Johnson	1:6714	003/004	NC
4010682	1992	4/28/95	E. Johnson	1:6319	008/009	CIR
4010687	1993	4/20/95	E. Johnson	1:7164	008/009	NC
4010714	1992	4/28/95	E. Johnson	1:7266	037/038	CIR
4010722	1994	1/31/95	E. Johnson	1:6818	045/046	NC
4010726	1995	5/9/96	E. Johnson	1:6752	008/009	NC
4010761	1994	2/1/95	E. Johnson	1:6520	040/041	NC
4010773	1993	4/20/95	E. Johnson	1:6798	013/014	NC
4010822	1994	2/1/95	E. Johnson	1:6314	028/029	NC
4010847	1994	2/1/95	E. Johnson	1:6575	033/034	NC
4010882	1995	5/14/97	E. Johnson	1:6500	072/073	NC

Table 2

Photointerpretation Comments - within 25-acre circle	
Plot Number	Comments - Within 25 acre circle
3710321	ravine bottom with oak and one-seeded juniper. disturbance: small dirt road. dry rocky site. gentle to steep slopes. all aspects.
3710345	mostly one-seed juniper with scattered common pinyon and Rocky mtn. juniper. small part of circle disturbed by check-dam building. steep, rocky canyonside. NW to NE aspects.
3710353	steep, dense, north facing pinyon and juniper. also - open, south facing ponderosa pine. disturbance: road
3710365	open stand of Utah juniper. no mortality found. disturbance: jeep road
3710414	mostly gambel oak with scattered common pinyon and Rocky Mountain juniper. aspect: NW to NE slope: moderate (approx. 35%).
3710416	mostly gambel oak and Rocky Mtn. juniper. some pinyon, Ponderosa, Doug.-fir and white fir. disturbance: minor trail. E, W, and N aspects, moderate to steep slopes.
3710436	pinyon and juniper with gambel oak. disturbance: roads, powerline, structures. no field data was available for the photo-interpretation.
3710448	Interpretation done without field notes. most likely spruce-fir w/ assoc. Doug.-fir and white fir. aspect: west

Plot Number	Comments - Within 25 acre circle
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3710488

all gambel oak. disturbance: fences, grazing

3710532

low incidence of scattered mortality found. disturbance: major unpaved road. steep valley side consisting of dense aspen, spruce-fir, and an open stand of bristlecone pine. elevation = 10,500 ft. steep slopes, E, SE, and S aspects.

3710552

scattered aspen in an open valley bottom. also, some scattered Doug.-fir and/or white fir. disturbance: roads

3710615

spruce-fir and aspen with large openings. steep slopes, southerly aspects

3710623

open stand of limber pine and Doug.-fir.

3710627

Doug.-fir/white fir mix with some aspen and scattered oak. small stream. disturbance: small road or trail. N, W, and S aspects. moderate slopes.

3710643

mostly open with scattered Doug.-fir, Ponderosa and oak. disturbance: small dirt road. N and S aspects. gentle to moderate slopes. elevation: 8,875 ft. dry site.

3710647

transition zone. Engelmann spruce, Doug.-fir, white fir, and aspen.

3710655

Plot Number	Comments - Within 25 acre circle
	mostly corkbark fir - Englemann spruce with some aspen. gentle to moderate slopes. all aspects. disturbance: small road
3710667	low incidence of old mortality and no new mortality. dense stand of spruce-fir (mostly spruce). NW aspects. moderate slopes. elevation: 10,800 ft.
3710712	mix of ponderosa, juniper, aspen and gambel oak.
3710716	pinyon/juniper type w/ open shrublands. small reservoir within circle (disturbance). gentle slopes. south, west and east aspects.
3710724	dry site consisting of Ponderosa pine.
3710731	half riparian type, half ponderosa/gamble oak type. southwest to west aspects. gentle to moderate slopes. disturbance: minor road/jeep trail
3710736	gambel oak and Doug.-fir. disturbance: cleared land.
3710743	moderate amount of scattered mortality. spruce-fir type. disturbance: previously logged; roads. W aspects. moderate slopes. elevation: 9,800 ft.
3710748	

Plot Number	Comments - Within 25 acre circle
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transition zone. Doug.-fir, aspen, subalpine fir and Engelmann spruce.

3710751

mostly open with some scattered spruce-fir (krumholtz). steep, exposed slope. west to southwest facing. field notes not available for this interpretation. typical scattered spruce-fir mortality found throughout photo.

3710771

mix of Douglas-fir and Engelmann spruce (transition zone). Dry, poor, exposed site. south to southwest aspects. moderate to steep slopes.

3710783

no stress or mortality found within the 25 acre circle. circle just above flood plain, mostly open with isolated dense aspen patches and scattered Englemann spruce . N aspects. moderate slopes. disturbance: small roads

3710824

common pinyon and Utah juniper. pinyon black stain apparant throughout. disturbance: jeep trail

3710832

woodland. mostly gamble oak with scattered ponderosa pine and an occasional pinyon pine. southeast to west aspects, gentle slopes. disturbance: road

3710844

open stand of Ponderosa. disturbance: small roads, stockpond (grazing ?). all aspects, gentle slopes. elevation: 7,500 ft.

3710852

Douglas-fir, ponderosa, aspen and gambel oak. aspect: east through south.

3710856

Plot Number	Comments - Within 25 acre circle
	gambel oak, common pinyon, and Utah juniper. disturbance: part of the circle is a cleared field (approx. 7 acres). north, east and south aspects (mostly east). gentle slopes.
3710858	open stand of common pinyon and Utah juniper.
3710864	gambel oak with occasional Ponderosa. (three off plot Ponderosa faders are marked). disturbance: stockpond/grazing
3710872	Englemann spruce/corkbark fir. logged around 10 years previous (disturbance). southerly aspects, gentle slopes.
3710876	mostly gamble oak with scattered pinyon and ponderosa pine. aspect: north to east facing. moderate slope. disturbance: jeep trail
3710888	common pinyon and Utah juniper. disturbance: mining
3810487	mostly gamble oak with ponderosa and scattered pinyon in an urban park (disturbance). all aspects. gentle to moderate slopes.
3810512	aspen, Englemann spruce, subalpine fir, and limber pine.
3810516	

Plot Number	Comments - Within 25 acre circle
	no damage or old mortality. Englemann spruce, primarily krumholtz. disturbance: area near circle's edge burned a long time ago. harsh subalpine site. southerly aspects. moderate slopes.
3810524	mostly open range with common pinyon. no mortality or stress found in photo. south facing. gentle slope. disturbance: cleared land
3810531	no stress or old mortality evident. open rangeland with a small, forested mesa side slope consisting of pinyon and juniper. disturbance: roads, grazing. W, NW aspects. gentle to moderate slopes. elevation: 5,820 ft.
3810536	open, rocky area with gambel oak, pinyon and juniper.
3810548	common pinyon and RM juniper. all aspects. gentle to moderate slopes. disturbance: roads
3810551	dry, rocky site. pinyon and juniper.
3810556	no recent damage or old mortality. dry site, steep hillside with Englemann spruce, limber and bristlecone pines, aspen and Douglas-fir. openings and rocky outcrops. N to NE aspects. moderate to steep slopes.
3810563	mostly open rangeland with gambel oak, ponderosa pine, and common pinyon. all aspects. moderate slopes. disturbance: jeep trails
3810571	

Plot Number	Comments - Within 25 acre circle
	no significant stress or mortality. an old burn is evident (disturbance) throughout most of photo. rocky outcrop consisting of Englemann spruce, limber and bristlecone pines, and aspen. southerly aspect. steep slope. elevation: 10,800 ft.
3810615	Englemann spruce w/ patches of aspen and a few limber pines. Old logging area with good regeneration (disturbance). most trees sapling to pole sized. west to northwest aspects. gentle slopes.
3810632	beaver ponds, willow, Englemann spruce, subalpine fir, lodgepole and aspen. north and south aspects. moderate slopes. elevation: 10,000 ft.
3810634	low stocked mix of ponderosa, lodgepole, Doug.-fir and aspen. all aspects. gentle slope.
3810652	mixed stand. transition zone. lodgepole, Ponderosa, Doug.-fir Engelmann spruce, aspen.
3810666	extremely low incidence of recent and old mortality throughout photo. dense stand of aspen with an occasional spruce or fir. S to SW aspects. moderate slopes. elevation: 10,100 ft.
3810672	mostly developed with houses, roads, and cleared fields (disturbance). narrow riparian strip bisects plot. no slopes, aspects.
3810678	open grassland, small aspen, some clumps of spruce-fir, a riparian area. all aspects. gentle slopes. disturbance: fencing, grazing
3810684	

Plot Number	Comments - Within 25 acre circle
	steep canyon bottom and surrounding slopes. aspen, lodgepole, Englemann spruce, and limber pine. south, west and north aspects. moderate to steep slopes. disturbance: road
3810686	open stand of lodgepole w\ scattered spruce and fir. a moderate amount of old, scattered lodgepole mortality found throughout. possible dwarf mistletoe. circle is the upper end of a minor drainage. gentle to moderate slopes. all aspects. 10,900 f t.
3810711	Engelmann spruce and aspen w/ open talus. all aspects. moderate slopes.
3810715	rocky and steep. spruce-fir stand. east facing
3810723	open stand of Ponderosa.
3810731	mix of Douglas-fir, aspen and Englemann spruce. northerly aspects. gentle to moderate slopes.
3810763	spruce-fir with some aspen.
3810767	common pinyon and Utah juniper on a mesa top and minor draw. the p/j stand is relatively open on the mesa top and fairly dense on the steeper slopes of the small draw. disturbance: small road, firewood cutting. NW to NE aspects. gentle to moderate slopes.
3810775	

Plot Number	Comments - Within 25 acre circle
	high altitude (elevation = 11,200 ft.) Engelmann spruce and subalpine fir stands, large dbh to krumholtz in size. very steep slope (approx. 90%) and rocky. all aspects.
3810782	scattered aspen mortality. aspen and gamble oak and openings. all aspects. gentle slopes. disturbance: Kebler pass road bisects circle.
3810812	ponderosa pine with pinyon and juniper. flat, open mesa top. all aspects. no field data available for photo interp. disturbance: roads, fencing, grazing
3810816	pinyon/juniper type. mesa top and steep north-facing canyon wall. gentle to steep slopes.
3810824	common pinyon and Utah juniper.
3810828	common pinyon and Utah juniper. xeric site. small mesa between goosenecks (of a river) and a steep, cliffed-out canyon slope of the Dolores river. no damage visible. all aspects. slope from moderate to vertical. elevation: 5,800 ft.
3810836	riparian area consisting of narrowleaf cottonwood and willow.
3810843	mainly aspen with some Ponderosa pine and Doug.-fir. moderate amounts of old standing aspen mortality. disturbance: aspen previously logged, old skidder trails evident. north aspects. gentle slopes. elevation: 8,700 ft.
3810856	

Plot Number	Comments - Within 25 acre circle
	healthy looking aspen stand. east aspect, gentle slope. disturbance: roads, fencing, grazing
3810863	common pinyon and Utah juniper.
3810868	low incidence of old and new mortality. common pinyon and Utah juniper. rocky, dry site. all aspects (predominantly E-SE). steep slopes. elevation: 6,040
3810875	mainly ponderosa pine with some some RM juniper, gambel oak and aspen. gentle slopes. all aspects (mainly easterly). disturbance: roads, grazing
3810888	open pinyon and juniper. disturbance: cleared land, roads, fencing
3910424	plot consists of some Ponderosa pine scattered along drainage. disturbance: cleared land, roads, fencing
3910436	ponderosa and gambel oak with cleared pastureland and structures (disturbance). gentle slopes. all aspects. No field data used for PI.
3910458	stand of gambel oak. disturbance: road
3910511	

Plot Number	Comments - Within 25 acre circle
	Ponderosa pine/ Doug.-fir mix with some aspen and an occasional limber pine. appears to be an area of old budworm/DFB activity. disturbance: highway; road
3910523	ponderosa growing on a poor site. gentle to moderate slopes. all aspects (mainly east through south).
3910535	lodgepole\Engelmann spruce mix. disturbance: mostly an old leave-tree cut with some clear cut areas (early 1970's?). The re-gen appears to be in good shape.
3910543	canyon bottom w/ surrounding steep slopes. Douglas-fir and ponderosa pine. all aspects (although mostly east and west). moderate to steep slopes. disturbance: road
3910547	moderate slope. west aspect. elevation = 10,500 ft. disturbance: road
3910555	no significant stress/mortality. limber, lodgepole and E. spruce. poor, rocky site. south facing. moderate slopes.
3910562	Doug.-fir on the north facing slope. open pinyon and gambel oak on the other aspects. moderate slopes. E, S, and N aspects.
3910567	dense stands of spruce-fir w/ some limber pine. north aspects, steep slope.
3910574	

Plot Number	Comments - Within 25 acre circle
	predominately lodgepole w\ some Douf.-fir and aspen. Ponderosa seen on open, south-facing slopes. polygons appear to consist mainly of old lodgepole mortality, but could also be old Doug.-fir mortality (old budworm). disturbance: parking lot, power line
3910587	mostly lodgepole (2nd growth after clearcut [disturbance]) with widespread old mortality (33%-50%) and some spruce in the drainage bottom. gentle to moderate slopes, all aspects. elevation = 9,200 ft. no field notes were available for the PI.
3910611	stand of Engelmann spruce.
3910626	very little recent or old mortality. a few faders. lodgepole with spruce-fir in scree and rocky outcrops. all aspects (predominatly S facing). steep slopes. elevation: 10,500 ft.
3910636	riparian area, aspen stands, lodgepole, and an old thinning unit (disturbance).
3910643	lodgepole stand with aspen. rocky talus outcrop. north and west aspects. moderate to steep slopes.
3910658	gambel oak (on the south facing slope), Doug.-fir & white fir (in the drainage bottom), and aspen (on the north facing slopes). moderate to steep slopes. south and north aspects. elevation = 8,200 ft. disturbance: road
3910663	subalpine zone. rocky outcrops and talus. spruce-fir. moderate to steep slopes. south to southwest aspects. elevation = 11,000 ft.
3910671	

Plot Number	Comments - Within 25 acre circle
	low to moderate amounts of old standing dead lodgepole scattered throughout. mostly lodgepole with a few fingers of spruce-fir. W to NW aspects. moderate to steep slopes. elevation: 10,150 ft.
3910715	aspen and gamble oak . all aspects. gentle slope. disturbance: roads
3910727	scattered subalpine fir faders (SAF decline) throughout (mainly smaller trees, dbh<8.0). spruce-fir, aspen and open, non-forested areas. northerly aspects. moderate slopes.
3910734	all aspen. gentle to moderate slopes. E, S, and W aspects (mostly south). elevation = 8,900 ft.
3910742	pinyon/juniper, gamble oak, cottonwood. disturbance: cleared land, structure, powerline. major road. mostly N facing. level and steep slopes.
3910746	open shrubland w\ assoc. Utah juiper, common pinyon and gambel oak. disturbance: cleared land, roads
3910762	open grass, open-grown Doug.-fir. aspen stands and Doug.-fir\aspen mix.
3910774	mostly open with clumps of spruce-fir. rocky to marshy. gentle slopes. west to south aspects. elevation = 10,600 ft.
3910778	

Plot Number	Comments - Within 25 acre circle
	Douglas-fir (north facing) and pinyon/juniper (south facing). north and south aspects. steep slopes.
3910811	mainly aspen with some spruce. open grass and marshland. flat to gentle slopes. elevation = 9,950 ft. no field data available for PI. disturbance: reservoir construction
3910835	mix of gambel oak, common pinyon and Utah juniper. slopes gentle to steep. all aspects. elevation = 6,600 ft.
3910843	entirely Utah juniper. very low incidence of recent or old mortality. all aspects. moderate slopes. elevation: 5,450 ft.
3910847	gambel oak with pinyon\juniper growing amongst rocky outcrops.
3910851	steep valley bottom with gamble oak and Doug.-fir on the exposed south facing slope and aspen, blue spruce and Doug.-fir on the northern aspects. steep slopes. all aspects. elevation = 7,600 ft. disturbance: road
3910855	consists of an aspen stand, an open field, and scattered Douglas-fir. north and east aspects. moderate to steep slopes. disturbance: road
3910867	scattered old pj mortality (low) found throughout. (*dead and downed trees were not tallied in the data). pinyon and juniper type with gamble oak located on a hilltop. all aspects. moderate slopes. elevation: 7,000 ft.
3910875	

Plot Number	Comments - Within 25 acre circle
	<p>dense stand of gambel oak on the north facing slopes and common pinyon on the southern aspects. no significant damage or mortality. disturbance: minor road</p>
3910883	<p>common pinyon and Utah juniper. small number of old standing dead visible - no recent activity. NW to NE aspects. gentle to moderate slopes. elevation = 6,500 ft.</p>
4010514	<p>mix of Doug.-fir, Ponderosa and Rocky Mtn. juniper. contains many old dead DF from the front range spruce budworm outbreak of the 1980's. disturbance: roads, structures. dry, open site (w/ a small riparian zone). S aspects. steep slopes. elevation = 7,600</p>
4010534	<p>Douglas-fir, ponderosa pine, and rocky mountain juniper. some of the described mortality (see PI data records) may be ponderosa. mortality most likely from the budworm outbreak of the 1980's. a very low incidence of recent beetle activity can be seen.</p>
4010538	<p>dense lodgepole, small stream w/ a few spruce and scattered aspen. some scattered old mortality (low). generally west aspects and moderate slopes.</p>
4010546	<p>dry, steep south facing slope with a many species mix - predominately lodgepole pine. elevation = 10,200 ft.</p>
4010554	<p>low incidence of old mortality. dense lodgepole with aspen in the drainage bottoms. disturbance: homes, small roads. all aspects. gentle to moderate slopes. elevation: 8,300 ft.</p>
4010558	<p>Engelmann spruce, subalpine fir, lodgepole pine and aspen. disturbance: road</p>
4010566	

Plot Number	Comments - Within 25 acre circle
	mostly lodgepole pine with a few Douglas-firs. north,east and south aspects. gentle slopes.
4010578	two lodgepole stands: one a doghair, the other more open on a drier site plus a couple of aspen fingers. very light mortality scattered throughout. various aspects. gentle slopes. elevation = 8,400 ft.
4010586	mainly second growth and doghair lodgepole (disturbance). north and east aspects. gentle slopes. elevation = 8,600 ft.
4010611	Douglas-fir w\ lodgepole and aspen.
4010615	lodgepole. Three distinct veg.patterns: 1) clear cut w/ good regeneration. 2) leave tree cut 3) uncut, mistletoe infested stand (causal agent determined from field notes) disturbance: logging; roads. SE to SW aspects. gentle slopes. elevation = 9,600 ft.
4010617	aspen with open grass. SW to W aspects. moderate slopes. elevation = 9,400 ft.
4010623	doghair lodgepole and aspen with some Doug.-fir and spruce-fir. south to west aspects. gentle slopes. elevation = 9,000 ft.
4010627	transition zone - mix of lodgepole, Douglas-fir, Englemann spruce, subalpine fir and aspen. northerly aspects. gentle to moderate slopes.
4010667	

Plot Number	Comments - Within 25 acre circle
	doghair lodgepole, spruce-fir, and aspen. north, east and west aspects. gentle slopes. disturbance: minor road
4010682	lodgepole, mainly a dense doghair thicket with a low level of mortality throughout. also some associated aspen and open meadows on a ridgetop. all aspects, gentle slope.
4010687	mix of lodgepole and spruce-fir type with scattered aspen. east through west aspects. flat to gentle slopes. elevation = 8,800 ft.
4010714	aspen stands, open meadows, and some (blue?) spruce in the drainage. southeast aspect. moderate slope.
4010722	spruce-fir type. faders = SAF decline.
4010726	mosaic of gentle-sloped aspen and gamble oak, steep rocky rift w/ Doug.-fir and spruce fir. disturbance: stock ponds - water damage from check-dam construction caused a significant amount of mort.. widespread aspen mort. throughout. N-NW aspects. 8000 ft
4010761	mostly aspen and gambel oak with scattered subalpine fir. denser stands of subalpine in south end of circle and extending outside. disturbance: roads, numerous cattle trails, grazing
4010773	open stand of spruce-fir. gentle slope. all aspects. elevation = 9,400 ft.
4010822	

Plot Number	Comments - Within 25 acre circle
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open shrubland with Utah juniper. disturbance: jeep road

4010847

open shrubland with Utah juniper

4010882

no damage/mortality visible. very dry, poor site with only a few trees. Utah juniper. all aspects. moderate slopes. elevation = 6,500 ft.

Table 1-16. Forest Mensuration Measurement Quality Objectives

Variables	Reporting Units	Data Quality Limits
SITE-TREE DATA		
Site-tree History	3 classes	95% agreement
Tree Type	2 classes	90% agreement
Tree Number	number	NA, downloaded
Point Number	4 classes	NA, arbitrary
Condition Class	9 classes	95% agreement
Species	314 classes	95% to genus, 90% to species
DBH	0.1 in (0.1 cm)	90% @ +/- 5% of True DBH
DBH Check	3 classes	90% agreement
Horizontal Distance	0.1 ft (0.1 m)	90% @ +/- 1 ft (0.3 m)
Azimuth	1°	90% @ +/- 10°
Crown Class	5 classes	85% agreement
Tree Height	1 foot (0.5 m)	90% @ +/- 3% of True Site Tree Height
Tree Age at DBH	years	90% @ +/- 5 years
Notes	2 classes	NA, discretionary
Description	alphanumeric field	NA, discretionary
Compelling Basal Area	ft ² /ac (m ² /ha)	90% @ +/- 20 sq ft (5 sq m)
POINT DESCRIPTION		
Point History	2 classes	90% agreement
Slope Correction	0.1 ft (0.1 m)	90% @ +/- 1 ft (0.3 m)
Percent Slope	1 percent	90% @ +/- 10%
Aspect	1°	90% @ +/- 30°
Terrain Position	7 classes	90% agreement
Subplot Condition List	9 classes	90% agreement
Subplot Center Condition	9 classes	90% agreement
Microplot Center Condition	9 classes	90% agreement
Subplot Offset	2 classes	90% agreement
Microplot Offset	2 classes	90% agreement

Table 1-16. Forest Mensuration Measurement Quality Objectives

Variables	Reporting Units	Data Quality Limits
PLOT IDENTIFICATION (FOREST)		
State	FIPS codes	99% agreement
County	FIPS codes	99% agreement
Hexagon Number	EMAP hex code	99% agreement
Plot Number	number	99% agreement
Measurement Type	3 classes	99% agreement
Project	2 classes	99% agreement
QA Status	3 classes	99% agreement
Crew Type	2 classes	99% agreement
Current Plot Status	6 classes	95% agreement
Month	12 classes	NA, crew dependent
Day	31 classes	NA, crew dependent
Year	31 classes	99% agreement
Elevation	100 ft (10 m)	90% @ +/- 200 ft (100 m)
Tally 1-5	FHM code	NA, crew dependent
CONDITION CLASSIFICATION		
Condition Class	9 classes	NA, arbitrary value
Land Use Class	15 classes	90% forest vs nonforest
Forest Type	122 classes	90% agreement to broad type
Stand Origin	3 classes	90% agreement
Stand Size	4 classes	85% agreement
Past Disturbance	17 classes	85% agreement
Disturbance Year	years	85% @ +/- 2 years
Stand Age	years	85% @ +/- 10 years

Table 1-16. Forest Mensuration Measurement Quality Objectives

Variables	Reporting Units	Data Quality Limits
MICROPLOT SAPLINGS		
Tree Number	number	NA, downloaded
Previous Condition Class	9 classes	NA, Downloaded
Condition Class	9 classes	90% agreement
Offset Point	5 classes	90% agreement
Current Tree History	14 classes	95% agreement
Fader (CA)	2 classes	90% agreement
Species	314 classes	95% to genus, 85% to species
Old DBH	0.1 in (0.1 cm)	NA, downloaded
DBH	0.1 in (0.1 cm)	90% @ +/- 5% of True DBH
DBH Check	3 classes	85% agreement
Stem Count	number	85% agreement
DRC	0.1 in (0.1 cm)	85% @ +/- 0.2 in (0.5 cm)
Horizontal Distance	1 ft (0.3 m)	90% @ +/- 1 ft (0.3 m)
Azimuth	1°	90% @ +/- 10°
Crown Class	5 classes	85% agreement
Notes	2 classes	NA, discretionary
Description	alphanumeric field	NA, discretionary

Table 1-16. Forest Mensuration Measurement Quality Objectives

Variables	Reporting Units	Data Quality Limits
BOUNDARY DELINEATION		
Plot Type	2 classes	95% agreement
Offset Point	5 classes	90% agreement
Contrasting Condition	9 classes	90% agreement
Left Azimuth	1°	90% @ +/- 15°
Left Distance	1 ft (0.3 m)	90% @ +/- 1 ft (0.3 m)
Corner Azimuth	1°	90% @ +/- 15°
Corner Distance	1 ft (0.3 m)	90% @ +/- 5 ft (2 m)
Right Azimuth	1°	90% @ +/- 15°
Right Distance	1 ft (0.3 m)	90% @ +/- 1 ft (0.3 m)
MICROPLOT UNDERSTORY VEGETATION		
Percent Moss	5% classes	90% @ +/- 20%
Percent Lichens	5% classes	90% @ +/- 20%
Percent Ferns	5% classes	90% @ +/- 20%
Percent Herbs	5% classes	90% @ +/- 20%
Percent Shrubs	5% classes	90% @ +/- 20%
Percent Seedlings	5% classes	90% @ +/- 20%
MICROPLOT SEEDLINGS		
Species	314 classes	90% to genus, 80% to species
Condition Class	9 classes	90% agreement
Crown Class	5 classes	85% agreement
Seedling Count	number	90% @ +/- 3
Crown Vigor Class	3 classes	90% agreement

Table 1-16. Forest Mensuration Measurement Quality Objectives

Variables	Reporting Units	Data Quality Limits
SUBPLOT TREES		
Tree Number	number	NA, downloaded
Condition Class	9 classes	90% agreement
Offset Point	5 classes	90% agreement
Current Tree History	14 classes	95% agreement
Fader (CA)	2 classes	90% agreement
Species	314 classes	95% to genus, 85% to species
DBH	0.1 in (0.1 cm)	90% @ + / - 5% of True DBH
DBH Check	3 classes	85% agreement
Stem Count	number	85% agreement
DRC	0.1 in (0.1 cm)	85% @ + / - 0.2 in (0.5 cm)
Horizontal Distance	1 ft (0.3 m)	90% @ + / - 1 ft (0.3 m)
Azimuth	1°	90% @ + / - 10°
Crown class	5 classes	85% agreement
Notes	2 classes	NA, discretionary
Description	alphanumeric field	NA, discretionary
PLOT IDENTIFICATION (NONFOREST)		
State	FIPS codes	99% agreement
County	FIPS codes	99% agreement
Hexagon Number	EMAP hex code	99% agreement
Plot Number	number	99% agreement
Measurement Type	3 classes	99% agreement
Project	2 classes	99% agreement
QA Status	3 classes	99% agreement
Crew Type	2 classes	99% agreement
Current Plot Status	6 classes	99% agreement
Month	12 classes	99% agreement
Day	31 classes	99% agreement
Year	number	99% agreement
Land Use at Point 1	15 classes	90% agreement
Land Use at Point 2	15 classes	90% agreement
Land Use at Point 3	15 classes	90% agreement
Land Use at Point 4	15 classes	90% agreement

Codes

Table 2-1 lists the PDR Prompt Codes.

Table 2-1. PDR Prompt Codes	
Variables	PDR Code
Seedling Measurements:	
Seedling Vigor	CmVlgr
Sapling Measurements	
Sapling Vigor	CmVlgr
Live Crown Ratio	CRatio
Trees >5.0 in dbh:	
Crown Diameter Wide	CrDiaW
Crown Diameter 90 Degrees	CrDia9
Live Crown Ratio	CRatio
Crown Density	CmDen
Crown Dieback	CmDbk
Foliage Transparency	FolTrn

The following are the codes for seedling vigor:

#Code	Definition
1	100 to 80% crown area with normal foliage, 1/3 or more of seedling height in foliage, and less than 5% dieback in the upper or outer-exposed portion of the crown.
2	79 to 21% crown area with normal foliage.
3	20 to 1% crown area with normal foliage.

The following are the codes for sapling vigor:

#Code	Definition
1	100 to 80% crown area with normal foliage, 1/3 or more of sapling height in foliage (greater than 30% live crown ratio), and less than 5% dieback in the upper or outer-exposed portion of the crown.
2	79 to 21% crown area with normal foliage.
3	20 to 1% crown area with normal foliage.

Table 2-2 lists codes which should be used for the Crown Diameter measurements.

Table 2-2. Crown Diameter Codes

Code	Definition (national)	Code	Definition (California)
00	Epicormic branches only	000	Epicormic branches only
01	< 1.5 ft	001	<0.15 m
02	1.6 to 2.5 ft	002	0.16 to 0.25 m
03	2.6 to 3.5 ft	003	0.26 to 0.35 m
.	.	.	.
99	>99.6 ft	995	>99.6 m

Table 2-3 lists codes which should be used for Live Crown Ratio, Crown Density, Crown Dieback, and Foliage Transparency.

Table 2-3 Live Crown Ratio, Crown Density, Crown Dieback, and Foliage Transparency Codes

Code	Definition	Code	Definition	Code	Definition
00	0%	35	31-35%	70	66-70%
05	1-5%	40	36-40%	75	71-75%
10	6-10%	45	41-45%	80	76-80%
15	11-15%	50	46-50%	85	81-85%
20	16-20%	55	51-55%	90	86-90%
25	21-25%	60	56-60%	95	91-95%
30	26-30%	65	61-65%	99	96-100%

Note: Class code is the percentage of the upper limit of the class, i.e. Code 10 is 6% to 10%, etc. Also for live crown ratio the code 00 is used for trees with epicormic branches only.

2.2 Sample Collections, Preservation, and Storage

No material samples are collected.

2.3 Equipment and Supplies

The list below includes all equipment and supplies needed for two persons to perform all measurements described in this section. All measurements are recorded on portable data recorders (PDRs).

- Binoculars - required, 1 set per field crew
- Crown Density - Foliage Transparency Card - required (provided), 1 for each field crew personnel

3.0 Quick Reference

Location Code	Definition
0	No damage
1	Roots (exposed) and "stump" (12 in [30 cm] in height) from ground level)
2	Roots and lower bole
3	Lower bole (lower half of the trunk between the "stump" and base of the live crown)
4	Lower and upper bole
5	Upper bole (upper half of the trunk between "stump" and base of the live crown)
6	Crownstem (main stem within the live crown area above the base of the live crown)
7	Branches (woody stems either the main stem ^{at present terminal})
8	Buds and shoots (the most recent year's growth)
9	Foliage

Damage Code	Description	Severity Threshold (in 10% classes to 99%)
01	Canker, Galls	20%
02	Conks, fruiting bodies, and other indicators of advanced decay	none*
03	Open wounds	20%
04	Resinosis or gummosis	20%
11	Broken bole or roots less than 3 ft (0.91 m) from bole	none
12	Brooms on roots or bole	none
13	Broken or dead roots(>3 feet from bole)	20%
21	Loss of apical dominance, dead terminal	1%
22	Broken or dead branches	20%
23	Excessive branching or brooms	20%
24	Damaged foliage buds or shoots	30%
25	Discoloration of foliage	30%
31	Other	none

*20% for roots >3 feet from bole or branches.

7.1 Overview

7.1.1 Scope and Application

The purpose of the lichen community Indicator is to use lichen species and communities as blomonitors of change in air quality, climate change, and/or change in the structure of the forest community. Lichen communities are excellent indicators of air quality, particularly long-term averages of sulfur dioxide concentrations (Hawksworth and Rose, 1976; Smith et al., 1993; van Dobben, 1993).

Lichen communities provide information relevant to several key assessment questions, including those concerning the contamination of natural resources, biodiversity, and sustainability of timber production (Figure 7-1). Lichens not only indicate the health of our forests, but there is a clearly established linkage to environmental stressors, as described below.

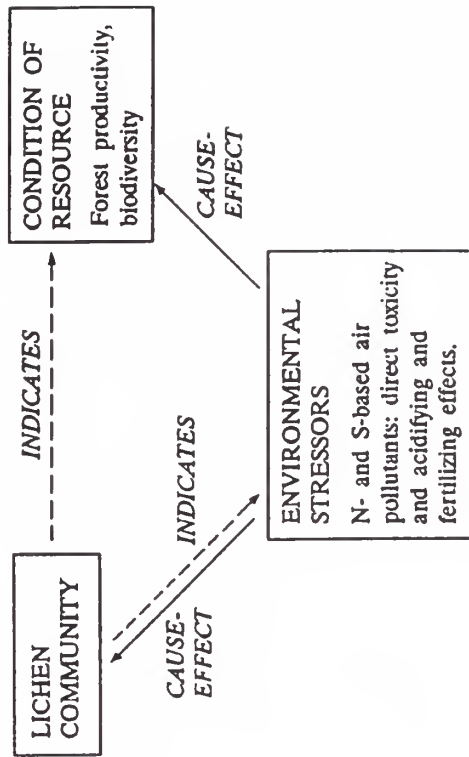


Figure 7-1. Conceptual model of the lichen community indicator.

